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SYMPOSIUM ON THE RED RIVER FLOOD OF 1997 INVOLVING SCIENCE IN FUTURE WATERSHED MANAGEMENT DECISIONS

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1996–1997

The Red River Water Management Consortium of the Energy & Environmental Research Center is pleased to co-sponsor a symposium offering public access to scientific perspectives on events associated with the Red River flood of 1997.

89th Annual Meeting

September 15-16, 1997

Grand Forks, North Dakota

SYMPOSIUM ON THE RED RIVER FLOOD OF 1997
INVOLVING SCIENCE IN FUTURE WATERSHED MANAGEMENT DECISIONS

ARCHAEOLOGY AND FLOOD DEPOSITS AT THE FORKS, WINNIPEG, MANITOBA, CANADA

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PREAMBLE

Archaeology, while concerned primarily with past human behaviour as exemplified in the preserved material culture, must also be cognizant of the environment within which the people lived. Changes in the environment, either short-term or long-term, will result in changes of the adaptive strategies employed for survival. Floods can produce both long-term and short-term effects upon the topography, flora, and fauna.

Topographical changes such as the cutting of new river channels may create oxbow lakes, which will increase harvest opportunities for waterfowl and edible plants such as cattail (*Typha*) and arrowhead (*Sagittaria*). Conversely, these changes may eliminate spawning localities, thereby reducing or changing fishing strategies in a specific region.

The effect of floods upon the vegetation in the riverine gallery forest will vary with the species and the depth of sediment deposition. Thin deposits of silts and clays may have minimal effect beyond enriching the soil. Thick deposits may suffocate some plants and cause short-term diminishment of some species until they reestablish themselves. This could cause modifications of the seasonal round if the species are important for food or medicine. Floral changes can cause displacement of faunal resources, which may also be in short supply locally due to decimation or relocation directly attributable to the flood.

For the past decade, numerous archaeological projects have been conducted at the junction of the Red and Assiniboine Rivers in Winnipeg. These projects have provided a window into the types of riverine sedimentation and raised the hope of being able to develop a chronological sequence of flood events. The standard textbook example of sedimentary stratification depicts layers of different soils; this layer-cake pattern does occur at The Forks (Figure 1). However, in a flood zone situation, this type of soil profile is actually an anomaly. In reality, over distances greater than 5 m (16.4 ft), the pattern of soil layering is more likely to resemble a marble cake. This is caused by irregular deposition and erosion during each high-water episode. Ice jams and deadfall jams can divert flow, causing erosion to the sides and deposition in the dead water behind. Uprooted trees leave large hollows, which may either be filled by sediment or enlarged and deepened by swirling water. The maelstrom of activity below the surface of the flood waters results in an uneven pattern of sedimentation different sizes of particles (sand, silt, or clay) are deposited in adjacent areas, and the thickness of the deposition varies. Excavation of long, continuous trenches during archaeological impact assessments has provided an opportunity to examine the continuity of strata over distance. It is not uncommon for a stratum, even a fairly thick one (10 to 15 cm; 0.3 - 0.5 ft), to pinch out and reappear 10 or 15 m (32.8 - 49.2 ft) away. Thus, interrelating disjunct strata over intervening distances, sometimes as little as 5 m (16.4 ft), is a major problem in determining synchroneity of cultural horizons.

A second problem occurs with the relocation of cultural material by moving water. Relatively moderate flows can lift and move charcoal and lighter bone, which become incorporated into the sediment load and redeposited at a new location. These flood-churned strata do contain archaeological data, but they have become separated from the primary locus of deposition, thereby minimizing any analytical value of recoveries from these strata. Due to the vagaries of water flow, the primary occupation site could be located in any direction at distances greater than twenty metres.

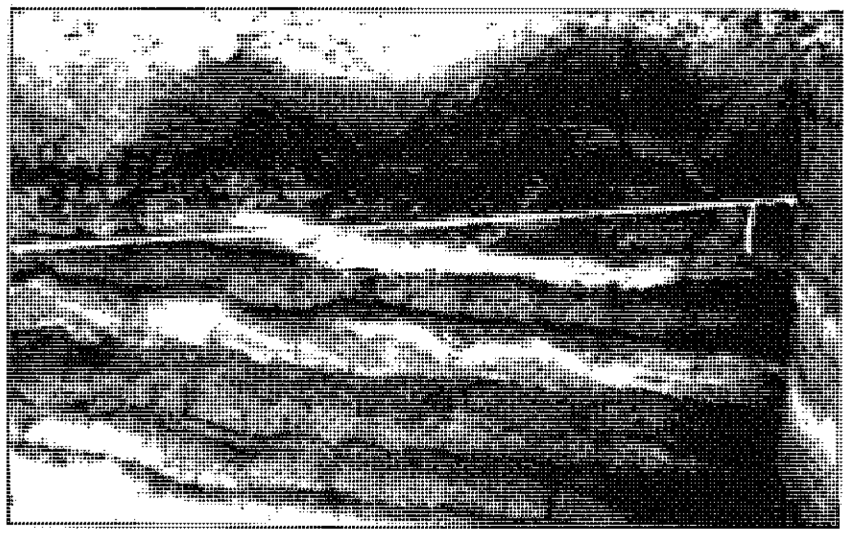


Figure 1. Stratigraphic sequence of horizontal layers.

CHRONOLOGICAL CORRELATIONS

Even when dealing with historic data, where the dates of the floods are known, it is often impossible to correlate the various strata with specific flood events. At Winnipeg, four major floods have been recorded during the 19th century 1826, 1852, 1861, and 1882. Only some of the strata recorded in the profile at the excavations of the North West Company post of Fort Gibraltar I can be definitely linked to specific events (1). This profile (Figure 2) has definite bounding limits. The fort was destroyed and burned by the Hudson s Bay Company in 1816, resulting in a thick layer of partially charred timber and fired chinking (the clay which had served as insullation between the logs). The Northern Pacific and Manitoba Railroad Company constructed a roundhouse immediately adjacent in 1888.

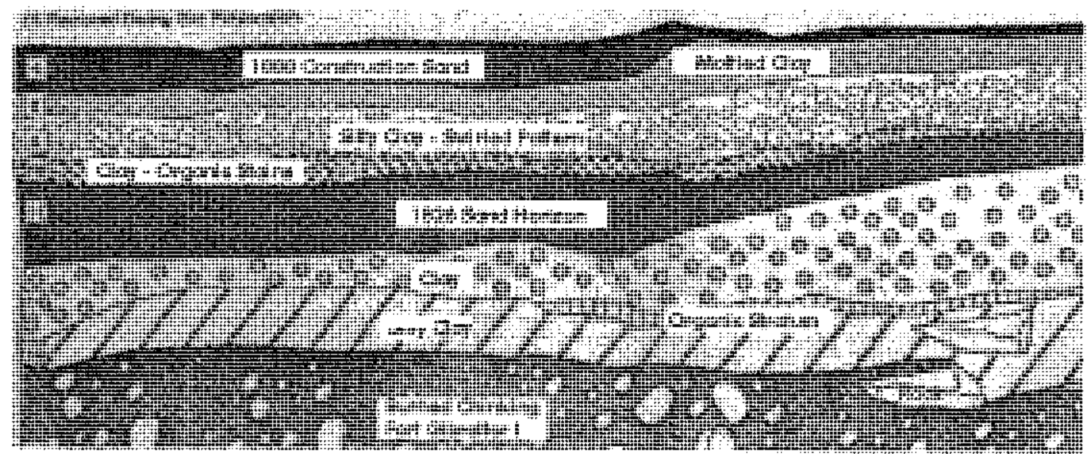


Figure 2. Soil profile at Fort Gibralter I.

Between the chinking layer, dating to 1816, and the construction sand layer of 1888, there are seven distinct strata. Layer 10, an organic-stained clay, contains manure and other deposits related to the Hudson s Bay Company Experimental Farm, which was in operation from 1836 to 1848. Therefore, this layer had to have been deposited prior to the 1852 flood, leaving four strata below it that derive from the 36-year period between the destruction of the fort and 1852. The 1826 flood, the most massive recorded at Winnipeg, would be responsible for the deposition of Layer 11, a sand stratum which varies in depth from 1 to 15 cm (0.3 - 0.5 ft), depending upon location. The organic clay horizon could be the final stage of deposition by the 1826 flood, as the waters were stagnant or receding, with resurgent vegetation providing the organic component. However, the three strata below the sand horizon present interpretive problems no floods, or even high-water episodes, are recorded in the historical archives. The lowest silty clay stratum had to be deposited after 1816, with sufficient time for an organic stratum to form above it prior to the deposition of the clay horizon. Similar interpretive problems occur with the upper strata: three floods (1852, 1861, and 1882) and only two layers. Artifacts recovered from the uppermost mottled clay horizon are ambiguous. Some, like shotgun cartridge shells, are relatively late, while others such as ceramic sherds and clay pipe fragments have temporal ranges from the 1840s to the early 1900s. The mottling derives from organic components in the soil matrix and indicates the presence of a humic horizon with a degree of vegetative cover. It is unlikely, therefore, that this horizon derives from the 1882 flood, as there would be insufficient time (6 years) to form an incipient A Horizon. Tentatively, the stratum is correlated with the 1861 flood and the underlying layer of silty clay, which has a swirled pattern, is attributed to the 1852 flood. Even when the events are known, as shown above, correlation of specific sediment strata with corresponding floods is often tentative.

The situation becomes even more tenuous when the events can be chronologically placed only through stratigraphic position, radiocarbon dates, and/or culturally diagnostic artifacts. Two examples will be presented. A massive sand horizon, predating the advent of Europeans to the area, occurs at several locations at The Forks. This horizon can range up to 1 m (3.3 ft) thick, indicating a very severe flood. By comparison, the deepest sand deposition attributable to the 1826 flood is 15 cm (0.5 ft). A section adjacent to the natural levee of the Assiniboine River was exposed during construction activity (Figure 3). Incorporated in the lower

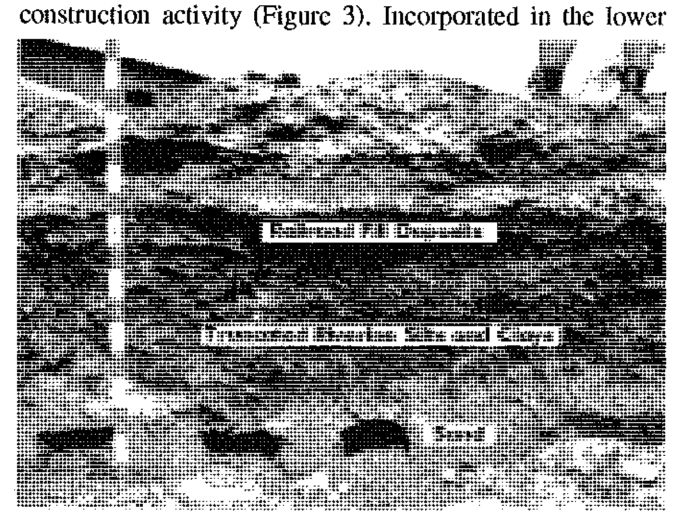


Figure 3. Sand stratum from the 750-Year flood.

portion of the stratum were the bones of a female bison (*Bison bison*) and foetal calf bones. The presence of the foetal bone indicates that the pregnant cow perished during the winter or spring of the major flood and was not reposited from another location. A radiocarbon date of 740 ±100 years B.P. was obtained from the bone (2), indicating that this massive flood occurred between 1100 and 1300 A.D. Pollen data indicate a major warming trend that appears to have climaxed at that time (3), correlating with the close of the Sub-Atlantic Period, as defined by Bryson, Baerreis and Wendland (4). The arid conditions would mean that soil in the catchment basin was more susceptible to erosion.

This flood stratum, while not firmly temporally placed, can provide limiting data for some cultural activities. The storage pit, depicted in Figure 4, was excavated down into the

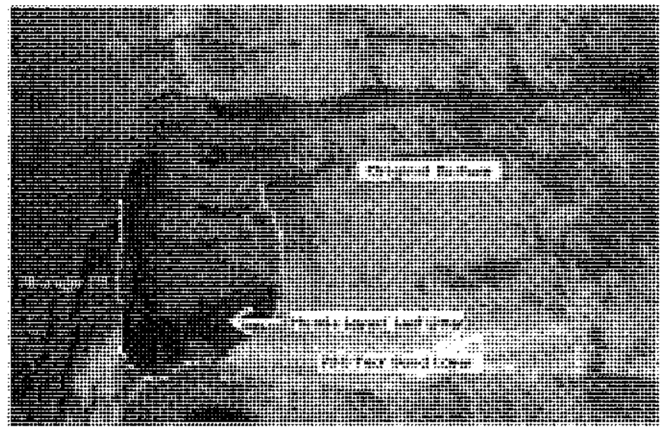


Figure 4. Storage pit - ca. 600 B.P.

top of the 750-Year-Flood sand stratum. The original surface at the time of the excavation appears to be a minimum of two depositional events after the sand layer. The pit appears to have been left open and accumulated leaf litter, which decayed into a humic deposit. A radiocarbon date would provide an upper limit for the activity. Unfortunately, the discovery occurred during a construction-monitoring project and the budget precluded obtaining a linear accelerator date on the organic material.

A major archaeological horizon, occurring at a depth of 3 m (9.8 ft) below the surface was dated at 2870 ±80 B.P. (5), 2850 ±90 B.P. (2, 6), and 2815 ±75 B.P. (6). Three distinct

Figure 5. Projectile points from the 3000-year old trade center and campsite.

types of projectile points (Figure 5) have been recovered from an extensive occupation site. The identification of these points as Hanna, Shield Archaic, and Pelican Lake (7) concur with the radiocarbon dates as the temporal ranges of each style of projectile point encompasses the dates for the site. The point styles are indicative of two different cultured groups from the prairie (Duncan/Hanna and Pelican Lake) and a boreal forest-adopted group meeting (Shield Archaic) and trading at the same locality. An adjacent portion of the site was interpreted as a bison-processing locality (8). Hearths and conglomerations of bison bone occurred at the same stratigraphic level–resting on a thick sand horizon that displayed considerable cross-bedding (Figure 6). The presence of this thick sand stratum represents either a massive flood similar to the 750-Year Flood or the cutting of the channel in which the Assiniboine River now flows.

The channel-cutting hypothesis differs from the current postulation that the Assiniboine River occupied its present channel approximately 1300 years ago (9). The presence of such massive quantities of sand, both above and below the cultural horizon, suggests that considerable sediment was being transported. Glacial till reaches the surface approximately 5 km (3.1 mi) upstream of The Forks along the Assiniboine, and this could be the source of these sand deposits. It is unlikely that this quantity of sand would be transported by the Red River, as the nearest sand source is many kilometers distant.

In summary, flood episodes provide both benefits and problems for interpretation of archaeological data. Sediment deposition can provide a layer of sediment over top of a horizon, thereby producing a sealed time capsule (Figure 7). Within that capsule are the tools and food remains of the people who occupied the site. Chemical and palynological analysis of the underlying soil can provide a picture of the contemporary environment in which the people undertook their activities: hunting, fishing, plant gathering, and tool manufacturing. An extraordinary example of a time capsule preserved by flood sediments occurs in the clay stratum below the 1826 flood sands at the Fort Gibraltar I site. Impressed into the clay are a series of prints cattle, horse, narrow-rimmed buggy wheels, and one moccasin-clad human foot (10). These prints (Figure 8) must have been made when the clay was wet and then dried or froze prior to the onset of the 1826 flood. The difference in textures between the clay and the overlying sands prevented melding of the sediments, and careful excavation exposed this scene of ephemeral activity, which has been preserved in plaster casts. It is tempting to visualize the scene as a frenetic rush from Fort Garry at the junction of the Red and Assiniboine Rivers as the waters began to rise. People on horseback, in buggies, and on foot, taking their belongings and driving their cattle toward higher ground, passed over this spot the afternoon before the flood. Overnight, the clay froze and the sand horizon was deposited as the first massive deluge slowed and spread over the

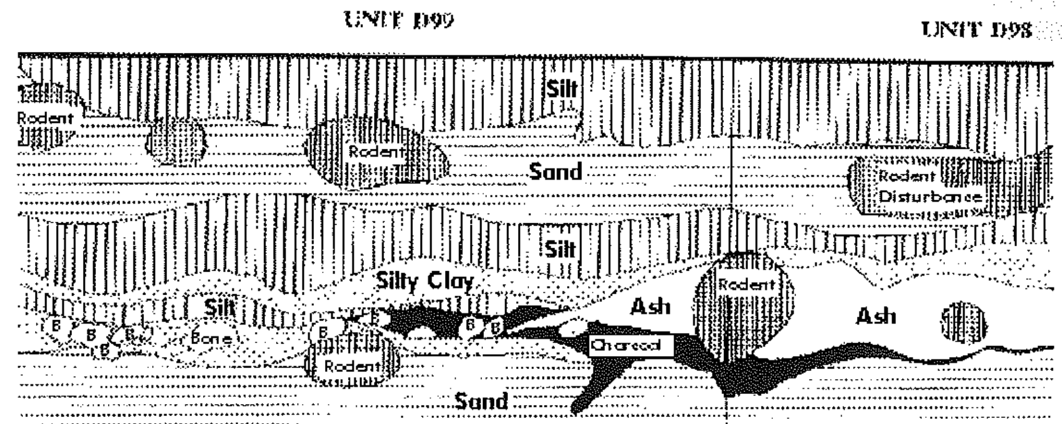


Figure 6. 3000-year old bison processing area.

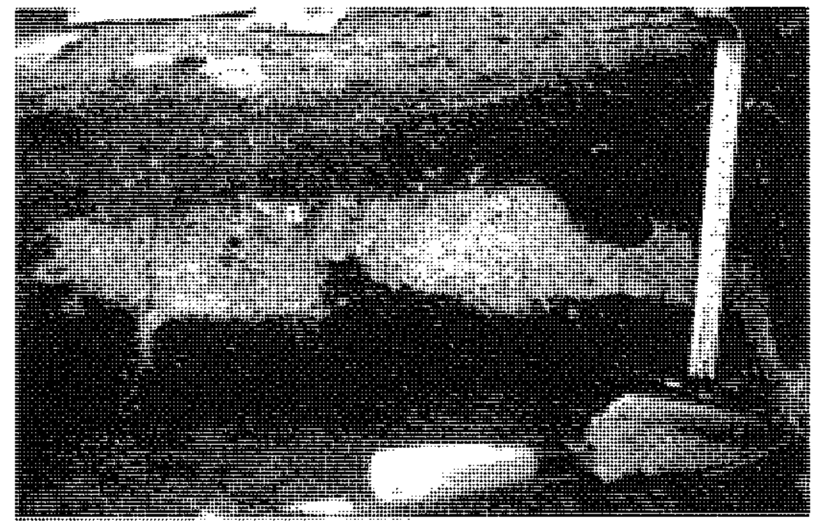
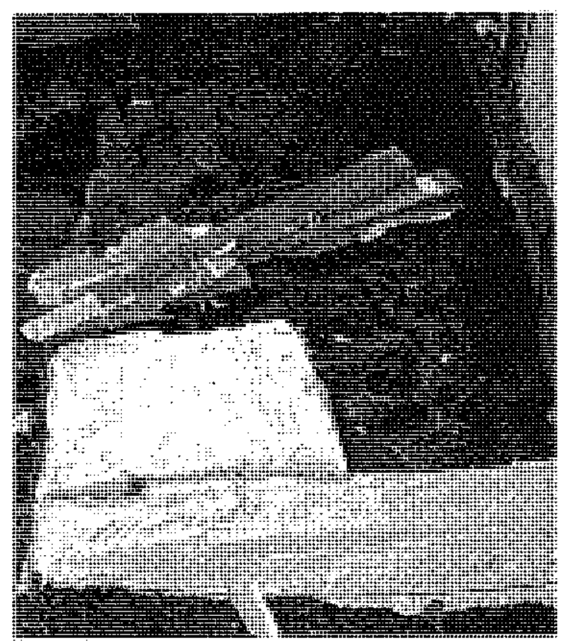


Figure 7. Hearth truncated by flood sediments.



Figue 8. Plaster preservatiou of prints.

Winnipeg area. On the down side, the flood waters often erase or relocate cultural deposits, which means that discoveries are often free-floating in a temporal sense.

When archaeological activity began at The Forks, the archaeologists naively believed that Quaternary geologists and sedimentologists could provide a temporal chart within which the cultural manifestations could be easily placed. At the same time, those scientists believed that the culturally diagnostic artifacts deriving from archaeological sites would firmly date major depositional events. Both parties, now convinced that there are no easy answers to the chronology, work together to attempt to provide a useable framework. At some localities at The Forks, there are 10 m (33 ft) of riverine sediments resting on Glacial Lake Agassiz clay. Somewhere in those sediments, deposited after the lake drained 8500 years ago, is the "perfect profile" that has a representation of every flood event and enough organic material in the strata to provide radiocarbon dates for each and every event.

REFERENCES

1. Kroker, S., Greco, B. B., and Thomson, S. (1991) 1990 Investigations at Fort Gibraltar I: The Forks Public Archaeology Project. Canadian Parks Service, The Forks Renewal Corporation, Historic Resources Branch of Manitoba Culture, Heritage and Citizenship, Winnipeg.
2. Kroker, S., and Goundry, P. (1990) Archaeological monitoring of the Stage I Construction Program. The Forks Renewal Corporation, Winnipeg.
3. Bernabo, J. C. (1981) Quantitative estimates of temperature changes over the last 2700 years in Michigan based upon pollen data. Quaternary Research 15:143-159.
4. Bryson, R.A., Baerreis, D.A., and Wendland, W.M. (1970) The character of late-glacial and post-glacial climatic changes. In Pleistocene and Recent Environments of the Central Great Plains (Dort, W., and Jones, J.K. Jr., eds), pp 53-74. University of Kansas, Department of Geology, Special Publication 3.
5. Kroker, S. (1989) North Assiniboine node archaeological impact assessment. The Forks Renewal Corporation, Winnipeg.
6. Kroker, S., and Goundry, P. (1993) Archaeological monitoring and mitigation of the Assiniboine Riverfront Quay. The Forks Renewal Corporation, Winnipeg.
7. Kroker, S., and Goundry, P. (1994) Archaic occupations at The Forks. The Forks Public Archaeological Association, Inc., Winnipeg.
8. Quaternary Consultants Ltd. (1993) Archaeological mitigation of the Johnston Terminal Refurbishment Project. Marwest Management Canada Ltd., Winnipeg.
9. Rannie, W.F., Thorleifson, L.H., and Teller, J.T. (1989) Holocene evolution of the Assiniboine River paleochannels and Portage la Prairie alluvial fan. Canadian Journal of Earth Sciences, 26 pp 1834-1841.
10. Kroker, S., Greco, B. B., and Peach, K. (1992) 1991 Investigations at Fort Gibraltar I: The Forks Public Archaeology Project. The Forks Public Archaeological Association, Inc., Winnipeg.

FACTORS AFFECTING FLOODING IN THE RED RIVER VALLEY

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INTRODUCTION

The cities of Grand Forks and East Grand Forks (North Dakota and Minnesota) suffered a devastating flood in April of 1997 that inundated 80% of the cities and forced almost total evacuation of the population (1). In the weeks and months following the flood, frustrated citizens and officials have charged that various agencies provided inaccurate forecasts of flood levels. Could the forecasts have been more accurate? Statements have also been made that the flood happened because not enough water is stored in wetlands or because farmers have illegally drained the land.

It has been charged that, despite the knowledge that total snowfall accumulation in the Red River drainage basin was at an all-time high (Fargo, 70 mi [113 km] upstream, had received the greatest snowfall in its recorded history - 115 in [2.92 m]) and despite reports that soil in the Red River Valley was saturated from heavy moisture the year before, the National Weather Service did not waver from its prediction that the river would reach a gage level of 49 ft (14.9 m) in Grand Forks, about the same as the 1979 flood, the flood of record in the area.

What are the factors affecting flooding in the Red River Valley? Is it possible to predict, with anything approaching certainty or accuracy, how serious a flood will occur in any given year? Or, perhaps, would it be as effective to simply visit with the old-timers in the county, who this year after walking through their fields following the seventh snowstorm, commented something to the effect: "Pretty wet out there. Never seen nothin' like it. It's gonna be a bad one" (1).

I believe there is a scientific approach to understanding the flooding problem (even though I cannot guarantee that it will be any more accurate than listening to the old-timers). Geologists at the North Dakota Geological Survey have identified a variety of constant and variable factors that affect or contribute to flooding in the Red River Valley (2).

DISCUSSION

Constant Factors

Direction of River Flow. The northerly flow of the Red River can affect the timing of the thaw. If the snowmelt occurs in the south before melting has begun in the north, the water can flow from a thawed to a frozen area, causing ice jams and other problems.

Drainage Ditches. Even though they are constructed features, once built, drainage ditches have a constant effect year after year. Drainage ditches result in faster and more complete runoff to the river. Water once stored on the flatlands bordering the river is now poured into the river during the spring thaw.

More than 28,000 mi (45,060 km) of legal, human-made ditches have been constructed in the Red River Valley of North Dakota and Minnesota. The main effect of the ditches, apart from the fact that they help to drain the farmland (as intended), is that they move water from the land to the river much more quickly than do the natural tributaries. In short, they result in water arriving at the river sooner than it otherwise would.

Rural Road System. The rural road system plays an important role in determining the manner in which water runs off the land. In many places where culverts are too small to handle a large flow, water becomes dammed against the roads. When the snow cover melts, water pours over the land, washing out bridges and stripping the gravel off the roads.

The Gradient of the Red River. The gradient (slope) of the Red River is exceptionally flat, a combined result of the deposition of sediment on the floor of glacial Lake Agassiz and of glacial rebound, which has differentially raised northern areas more than it has southern areas.

The modern gradient on the Red River is about 16 in/mi (25 cm/km) downstream from Wahpeton; 11 in/mi (17 cm/km) downstream from Fargo; 7 in/mi (11 cm/km) downstream from Grand Forks; about 4 in/mi (6.3 cm/km) downstream from Pembina. At Winnipeg the gradient is 3 in/mi (4.7 cm/km), and it is even less north of there. River gradient is an important factor because it controls the flow velocity. A low gradient causes the river to drain very slowly.

Flow Velocity. The velocity of flowing water is approximately proportional to the square root of the gradient (Manning's Equation). For example, at Fargo, the river gradient is about 0.9 ft/mi (0.17 m/km). The gradient along a drainage ditch arriving at Fargo from the west is about 3.6 ft/mi (0.68 m/km), four times the gradient on the Red River. Since the square root of four is two, drainage ditches entering the Red River in the Fargo area deliver water to the river about twice as fast as the river can carry it away without flooding.